August 29, 2014
Ref. A14129-LR-001, Rev. 0

Mr. Richard Tilley
Electric Power Research Institute
1300 West W.T. Harris Blvd.
Charlotte, NC 28262

Dr. Thomas Rosseel
Oak Ridge National Laboratory (ORNL)
P.O. Box 2008
Oak Ridge, TN 37831

Subject: Joint Demonstration Project Completion Work at R. E. Ginna Nuclear Power Plant – Assessment of Temperature in Containment

Ref. UT-Battelle Contract No. 4000130497, EPRI Contract MA 10002327

Dear Mr. Tilley and Dr. Rosseel:

The behavior of the concrete in nuclear containment structures has been evaluated as part of the Long Term Operation (LTO) program at EPRI and the Light Water Reactor Sustainability Program from the DOE. Under the joint demonstration project, Constellation Energy Nuclear Group (CENG) provided access to R. E. Ginna and Nine Mile Point Unit 1 for assessment as part of the LTO program. In support of these activities, LPI, Inc. (LPI) has prepared a number of documents and assessments. One specific item was associated with the Containment Inspection Guide, which was prepared and issued [1][1]. Currently a number of items associated with the containment are being completed. This letter report summarizes activities and results associated with assessment of temperature in containment. The work is associated with the above referenced UT-Battelle and EPRI contracts.

[1] Numbers in [1], i.e. 1 refer to a list of references listed in Section 5.0.

1.0 BACKGROUND

The behavior of the containment is affected by loads, radiation, external environment, and temperature. The identified containment stressors have been assessed in several reports [1 to 5]. Temperature as a stressor is addressed herein.

For a typical PWR or BWR, air temperatures are controlled through recirculating the containment or drywell air through fan cooler units, which are cooled by cooling water systems. Based on industry experience and interviews with plant personnel at Ginna and Nine Mile Point Unit 1, it was concluded that the PWR containment is most limiting from a temperature standpoint. Using plant data and plant personnel experience, it was determined that other than the reactor cavity, the pressurizer cubicle[2] was potentially the hottest location in the containment. See Figure 1-1 for typical containment layout.

The reactor cavity concrete temperature was evaluated in [5]. In that study, the temperature of the reactor cavity was presumed to be no higher than 150°F, based on a preponderance of plants using forced circulation to bring containment air through this cavity[3]. As such, it is expected that most plants will operate near or below 150°F. With an inner surface wall temperature of 150°F, the maximum temperature in the shield wall was approximately 159°F. This was located at a depth of approximately 3.2" into the wall. This included the effect of the ambient temperature on the inside surface of the reactor cavity and the effects of radiation heating. Figure 1-2 provides a profile of the total temperature distribution in the concrete at the peak elevation.

To provide assurance of maximum concrete temperatures in containment, the temperature in the pressurizer cubicle at Ginna was monitored. Determination of the temperature of the concrete in the compartment around the pressurizer was determined to be a logical way to determine that the temperature in the containment was limited. Self-contained battery operated temperature data loggers (shown in Figure 1-3) were placed in the Ginna containment for one operating cycle. The installation is shown in Figure 1-4. Two temperature data loggers were installed in the pressurizer cubicle. One provided useful data. Two data loggers were installed on the outside of the reactor pedestal

---

[2] Often referred to as the pressurizer "doghouse", based on the method of access to the upper region through the cubicle wall.

[3]Typical PWR units maintain maximum operating internal containment ambient temperatures in the range of 130°F to 150°F. Forced movement of containment air is used to limit concrete temperature surrounding the reactor vessel.

concrete at a location where each hot leg penetrated the RPV support concrete. These did not provide useful data.

The maximum temperature recorded for the data collection period between November 11th, 2012 and May 15th, 2014 occurred on July 25th, 2013 and it was 130.7°F. A plot of the pressurizer compartment concrete temperature for this time period is shown in Figure 1-5. A comparison plot of pressurizer cubicle temperature and outside ambient temperature[4] for the time period the data logger was deployed is shown on Figure 1-6.

2.0 DISCUSSION ON CODES AND STANDARDS

Commercial nuclear power plant facilities and containment structures in particular have been designed in the United States to The American Concrete Institute (ACI) standards. Specifically most structures of early vintage plants were designed using ACI 318 [7]. Newer structures were designed or evaluated using ACI 349 [8] or ACI 359/ASME B&PV Code Section III, Div. 2 Subsection CC [9]. All three codes can be implemented at any one site to address both non-safety and safety related structures.

The ACI developed ACI 318 to provide minimum design and construction requirements for buildings. ACI has two committees specifically related to nuclear construction: ACI Committee 349 (Concrete Nuclear Structures) and ACI Committee 359 (Concrete Components for Nuclear Reactors). ACI Committee 349 has developed "Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349) and Commentary" [8]. ACI Committee 359 is a joint committee between ACI and ASME. This joint committee has developed the "Code for Concrete Containments – Rules for Construction of Nuclear Facility Components (ACI 359)" which is Section III Division 2 of the *2007 ASME Boiler and Pressure Vessel Code* [9]. ACI 349, and to a lesser extent, ACI 359 are based on modifications of ACI 318. They also clearly state the circumstances where ACI 318 is not applicable.

3.0 EVALUATION

The allowable temperature within the concrete is set within specific FSAR requirements. The basis of these values are typically established by the American Concrete Institute (ACI) code 318[7][5], ACI 349 [9], and ACI 359/ASME B&PV Div. 2 code [9]. The limitation according to the ACI 349 (2006 and earlier codes), Appendix A "Thermal Considerations" [8] and ASME Sect III, Div. 2 Subsection CC, paragraph CC-3440 code [9] is for

[4] As recorded at Rochester, NY airport [6]
[5] ACI 318 does not, within the body of the code, establish a sustained temperature limitation.

temperature limitations for normal operation or any other long term period. The temperatures shall not exceed 150ºF except for local areas, such as around penetrations, which are allowed to have increased temperatures not to exceed 200ºF. These limits are also stated in the Ginna FSAR [10] with the basis established by ACI 359/ASME CC-3440 [9].

The latest edition of ACI 349, Appendix E [11] permits temperature limits to be increased to 180ºF for general surface areas and 230ºF for local surface areas if the tested concrete strength at 28 days or more is equal to or greater than 115 percent of the specified 28 day concrete strength.

4.0 CONCLUSION

The maximum temperature recorded during one fuel operating cycle for the concrete of the pressurizer cubicle, considered as the most likely hottest location within the containment, remained well within concrete temperature limitations recommended by the ACI codes for sustained temperature exposure to concrete.

5.0 REFERENCES

1. LPI Report A12477-R-004, Rev. 0 “Augmented Containment Inspection Guide”, September 2013.
2. LPI Report A12191-R-001, Rev. 0 “Augmented Containment Inspection Results”, September 2012.
3. LPI Report A12477-R-003, Rev. 0 “Augmented Containment Inspection Results – Supplement to LPI A12191-R-001”, October 2013.
4. LPI Report A12477-R-002, Rev. 0 “Interim Report for Augmented Inspection at Ginna and Nine Mile Unit 1”, June 2013.
5. LPI Report A13276-R-001, Rev. 0 “Expected Condition of Concrete Exposed to Radiation at Age 80 Years of Reactor Operation”, December 2013.
6. NOAA temperature data for Rochester airport. http://nws.noaa.gov/
7. ACI 318, “Building Code Requirements for Structural Concrete”, American Concrete Institute.
8. ACI 349, “Code Requirements for Nuclear Safety Related Concrete Structures, American Concrete Institute, Reported by ACI Committee 349”.
9. ACI 359/ASME Boiler & Pressure Vessel, Div. 2 Subsection CC “Code for Concrete Containments – Rules for Construction of Nuclear Facility Components”.
10. Ginna UFSAR.

11. ACI 349 2013 Edition, “Code Requirements for Nuclear Safety Related Concrete Structures, American Concrete Institute, Reported by ACI Committee 349”.

This document is prepared in accordance with the requirements of the UT-Battelle and EPRI contracts. If you should have any questions, please do not hesitate to contact the undersigned.

Respectfully Submitted,

LPI, Inc.

Thomas C. Esselman
Principal

Paul M. Bruck
Principal

Cc: Dr. Jeremy Busby, ORNL, UT-Battelle
Dr. Joe Wall, EPRI
Mr. Michael Fallin, CENG/Exelon

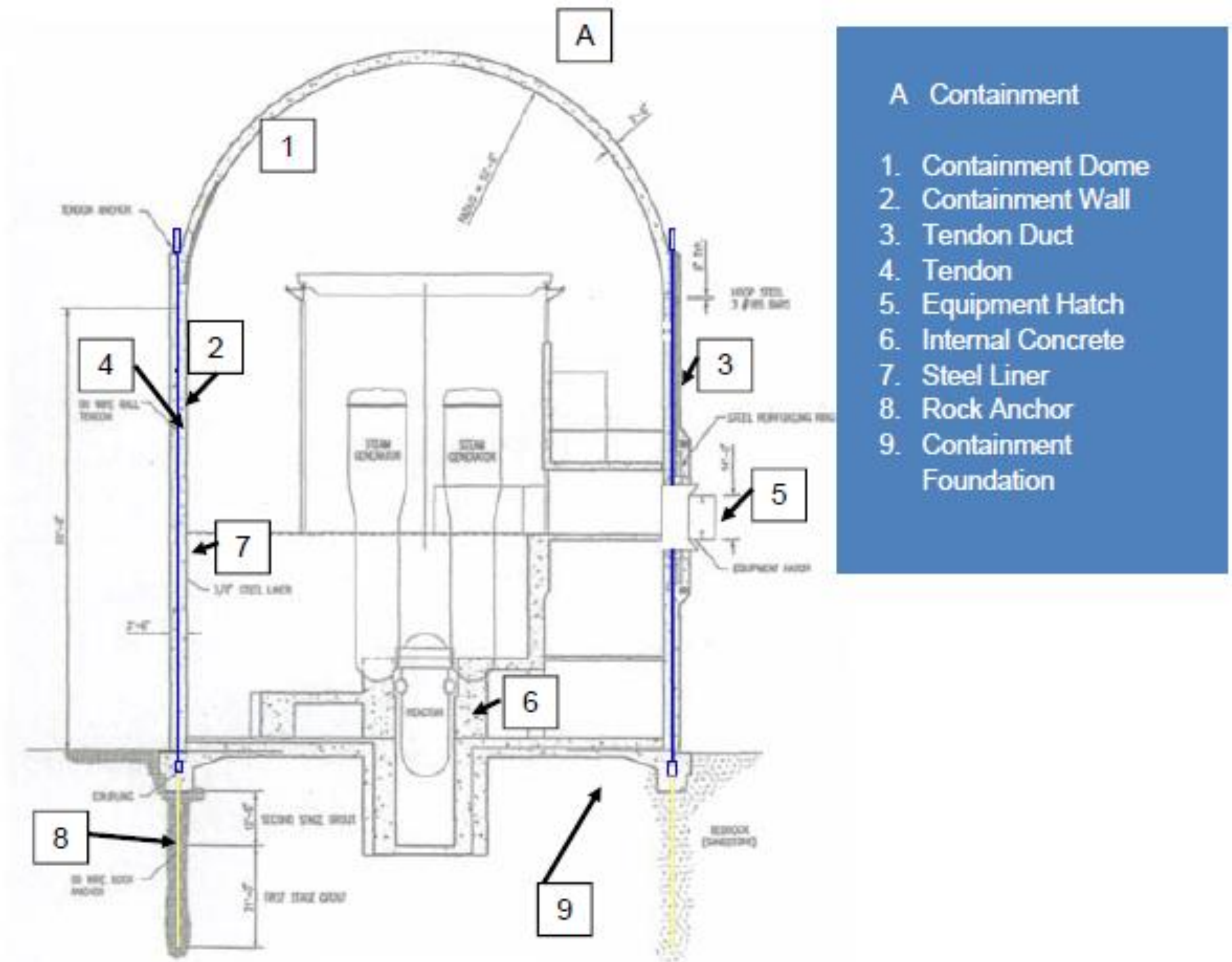

Figure 1-1: Configuration of Ginna Containment

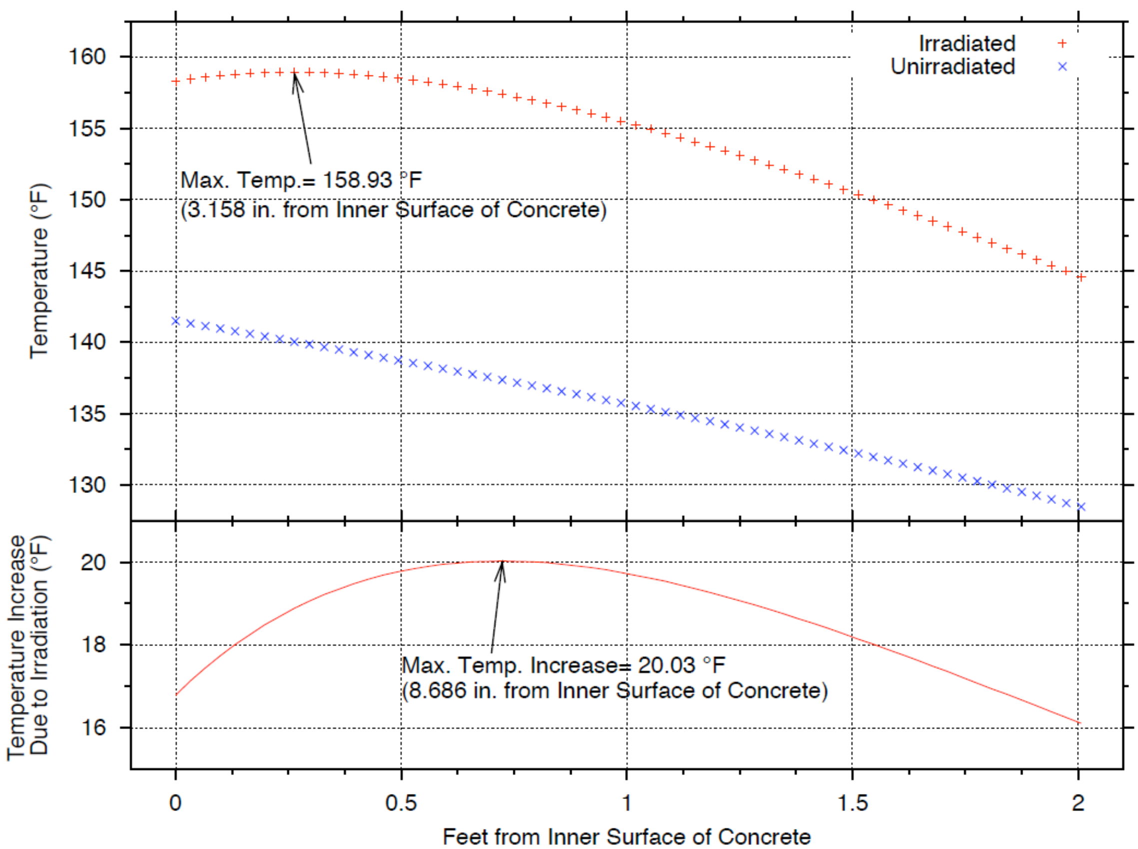

Figure 1-2: Temperature at Reactor Cavity, including effects of Gamma Radiation Heating [5]

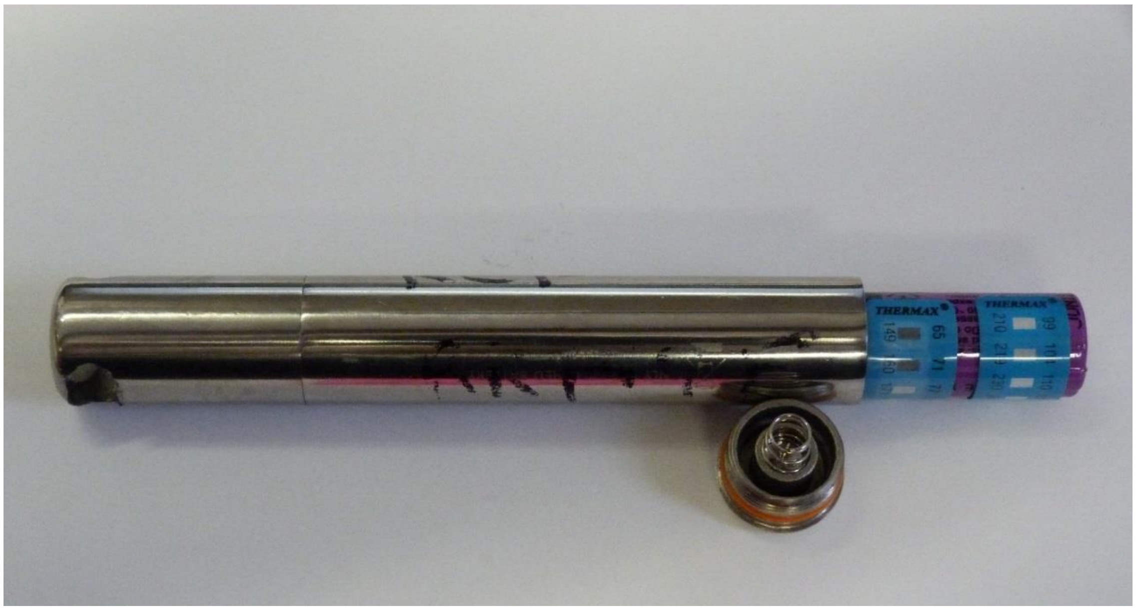

Figure 1-3: Typical Temperature Data Logger (with Thermax Strip) Inserted

Figure 1-4: Installation of Temperature Loggers in Containment Pressurizer Cubicle

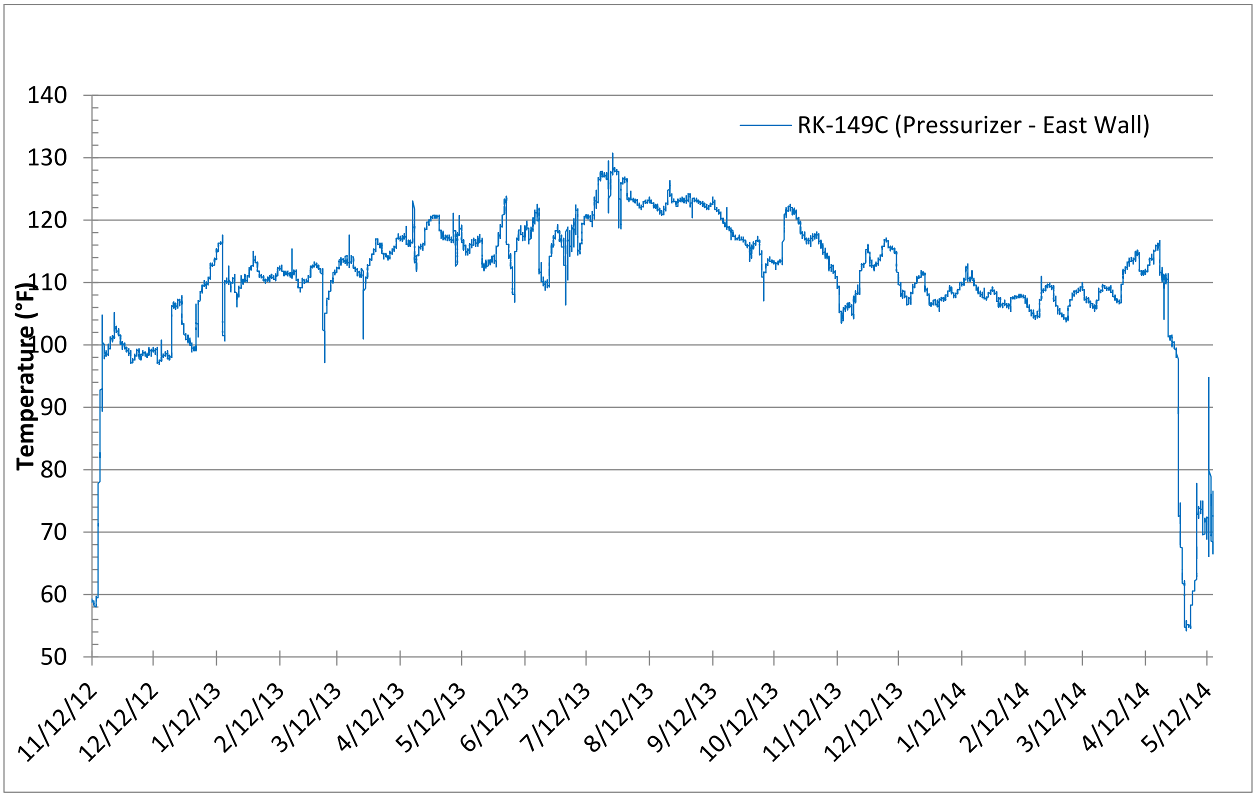

Figure 1-5: Containment Pressurizer Cubicle Concrete Temperature Plot

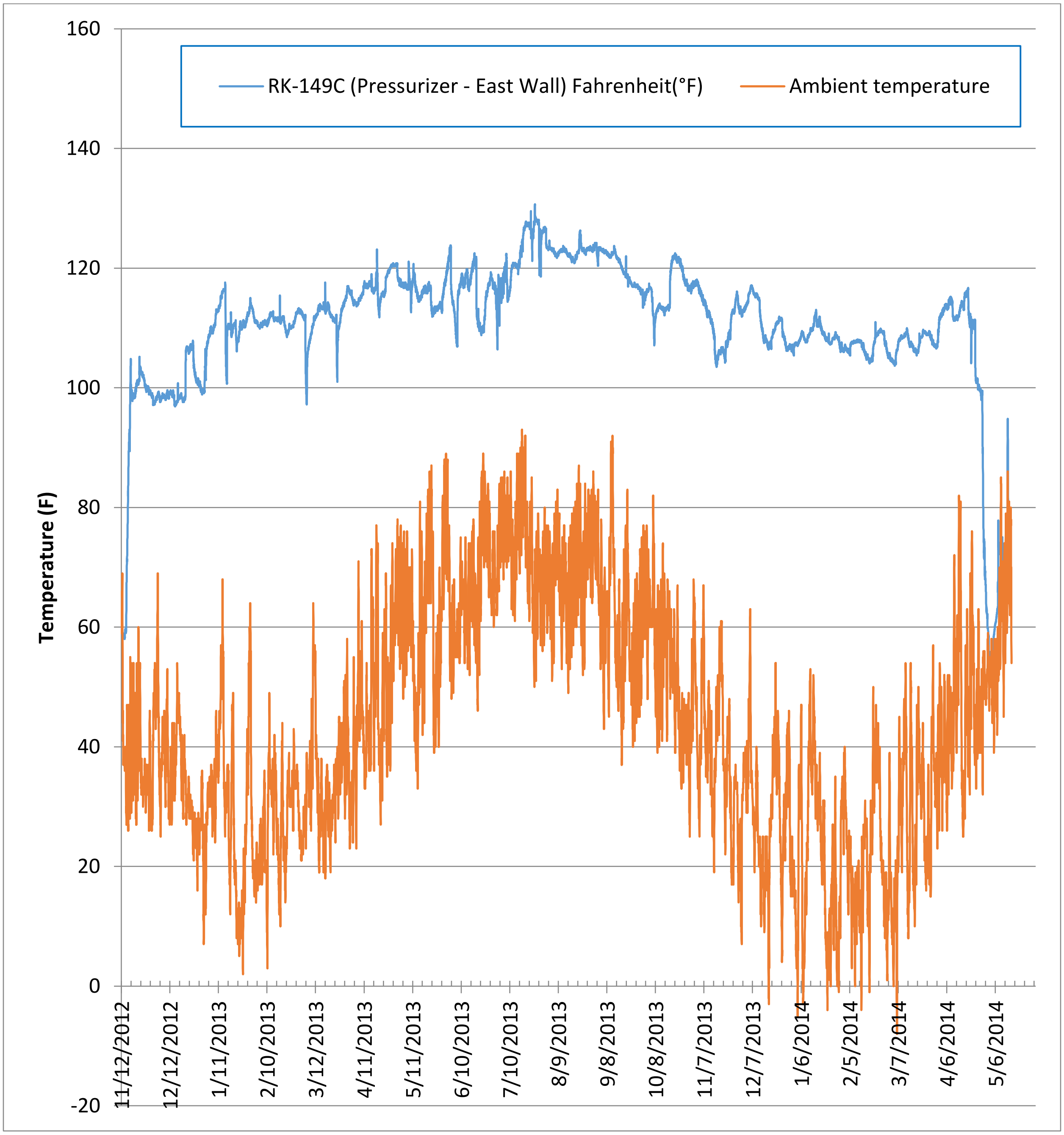

Figure 1-6: Pressurizer Cubicle Compartment Concrete Temperature, and Outside Ambient Temperatures